Invention title:
Improved Low Tare Weight Filter Design

Specification:

This provisional patent pertains to improvements in the design of particulate filter assemblies using a filter means and filter holding means that are used for real time particulate mass collection systems such as those described in the following patents: 7,285,736 and 6,444,927 and 6.205,842 and the many other variants utilizing a filter collection means integrated with a filter holding means to comprise a filter assembly.

The improved design can be used for the purpose of collecting particulate in real time and in applications where a low tare weight is required, such as inline filter holders. In these patents we are taught that a filter and filter holder is affixed to the end of a resonant structure, much like a tuning fork, and the mass of the filter is proportional to the frequency of oscillation. In practice the filter and filter holder are one and the same and the filter is not replaceable. In practice a new clean filter and filter holder are attached to the end of the resonant structure. To determine the mass of the assembly the resonant frequency of the filter and filter holder is recorded in a clean state. As the filter loads up with particulate the mass of the filter and filter holder increases by virtue of particulate collecting on the filter collection means. Using the differences of resonant frequencies, in the clean and dirty state, and as shown in the reference patents, one can infer the mass of the filter and filter holder in real time.

Problematic with the current filter and filter holder design is that they are heavy. The novel concept of this patent is that I have invented a means to separate the filter and filter holder creating a separable particulate filter assembly consisting of a filter collection means and a filter holding means. The technology to accomplish this is concurrent with advancements in the 2008 year with regards to SLA, SLS, and 3D printing technology. One advancement in the 2008 yeas was the spot size of the laser that accomplishes the buildup of the solid material to allow for producing a low mass filter holding means. The spot size has gone form 100 mils to 2 mils and the smaller the spot size gets the smaller characteristic dimension can be fabricated using these technologies.

The filter means and filter holding means in the patents described above are integrated into a single filter assembly where the filter collection means is securely fastened, to prevent leaks, to the filter holding means. A complete filter assembly's mass consists of the filter holding means and the filter means.

A design paramater of prior art has been to decrease the entire mass of the filter assembly. Classically, this has been done by reducing the mass of the filter holding means by utilizing various geometric designs that maintain sufficient strength and rigidity to allow the filter holding means to survive in the operational environment.

These filter collection means range from sizes as small as 19 mm up to 47mm in diameter. I will describe elements of the 37 mm diameter filter in this specification

knowing that similar descriptions hold true for the 19mm and 47mm diameter filter collection means.

The filter collection means typically consists of an expanded PTFE material, Teflon, with a nominal thickness of 50 microns. Additionally, in the current art, this 50 micron thick Teflon is bonded to a backing to support the weak Teflon filter material. This backing is typically a non woven material that is typically between 100 to 500 microns thick. The backing typically weighs at least 2 to 3 times the weight of the Teflon filter.

When the filter collection means is secured to a 37 mm diameter filter holding means the entire assembly's mass, see Fig. 15, can approach 1000 milligrams while the 19 mm diameter filter holding means can approach a weight 100 milligrams.

When we separate the filter holding means from the filter collection means we now have a filter collection means that can approach one tenth the mass of the entire filter assembly of the prior art. The advantage of the reduction in tare weight, the weight of the filter when it is clean, is that the filter holding means can be optionally integrated into the resonant structure so that the change in resonant frequency will be fully reflective of the change in the mass of the filter collection means, and the particulate alone. Additionally, wet chemistry can be performed on the filter collection means without having to dissolve the filter holding means.

Prior art has demonstrated that the filter collection means consists of a filter holder assembly that consists of a filter support means and a filter collection media secured to the filter support means. As such the prior art design has been focused on a "disposable" filter collection means and filter holder means. In this patent I propose that the filter holding means and the filter collection means be seperable and only the filter collection means is disposable. Of course the filter holding means can be used many times but could be disposable as well. Utilizing a design such as this allows the filter holding means to be integrated with the resonant structure.

In order to attain the design goals the filter collection means consists of single or multiple Teflon filter supported by a support ring. There are applications in particulate collection where two filters are stacked on one another to allow the second, downstream filter, collect the particulate that was too small to be trapped by the top filter. This configuration is known as a cascaded filter design.

The support ring material is selected to allow "welding" the Teflon to the support ring. I would liken the support ring to a hula hoop and the Teflon film as a soap film, much like you see when kids dip a hula hoop in soap to blow big bubbles. The difference is the Teflon filter, or equivalent filtration material, (such as paper or glass fiber) is securely affixed to the underside of the support ring.

Additionally, the support ring is designed so that it can slide firmly over the filter holding means and remain in place under vibrational loading. A fixture is used to install and uninstall the filter collection means without damage. This fixture is designed to act as a

Petri dish for storage as well as an installation and removal too with an area for writing data.

Additionally, an important element of this patent is that, rather than having the filter holding means flat, my design has a slight curvature so that the Teflon filter can stretch tightly and firmly over the filter holding means. Having this slight curvature allows for the filter collection means and filter holding means to be in intimate contact and an unmovable assembly.

The prior art additionally suffers from the filter collection means bulging up until a vacuum is established which, after the filter has been slightly loaded, causes the filter collection means to be in intimate contact with the filter support means. When such a filter collection means us used in a resonant structure assembly, as described in the above patents, the movement of the filter from bulging up to being in intimate contact with the filter holding means appears to be a decrease in mass and throws off the zero reading to a negative number.

My patent is an improvement in the basic design of filter assembly philosophy. One salient element that serves to resolve these problems is to have the filter support means present a slightly curved surface to the filter collection means.

Another problem this patent addresses is the basic calibration of a resonant structure that is based on proper and repeatable attachment of the filter collection assembly in the prior art. If the filter assembly is not properly seated with the resonant structure large errors in basic calibration can occur, causing the data to be invalid, which can be very costly. Given that this new design has the filter holding means affixed to the resonant structure will yield a more repeatable and accurate mass indication.

My improved filter design can be utilized as an after market filter for the various filter designs that suffer from elements addressed by this new design concept.

Description of Drawings:

The drawings illustrate an exemplary embodiment consisting of a 37 mm diameter filter collection means using Teflon filter media secured to a chemically compatible support ring and utilizing an electroformed curved filter support screen. Other embodiments consist of any filter media, such as glass fiber or paper type filters as well as filter support screens made utilizing other manufacturing methodologies such as chemically etching and sintered assemblies.

Fig. 1 shows a resonant structure with a filter assembly, m, resonating at frequency, f, by virtue of the physics explained in the above mentioned patents. The goal is to minimize the mass of mass, m and is the subject of this patent. The circled elements represent the mass, m and we can see that the complete filter assembly is comprised of a number of parts.

Fig. 2 shows a filter collection means consisting of Teflon filter media and a support ring in an assembly in the stretched position over a slightly curved filter holding means. This assembly is called the filter collection means.

Fig. 3 shows a cutaway of Fig.2 showing the Teflon filter media attached to the filter support ring. Note the Teflon filter media is attached on the interior of the filter support ring so that the Teflon filter media is in intimate contact with the filter holding means.

Fig. 4 shows a Teflon filter media and supporting ring as an assembly in the as built configuration prior to it being installed on the filter holding means.

Fig. 5 shows a cutaway of Fig.4 showing the Teflon filter and support ring that comprise the filter collection means before the filter collection means is attached to the filter holding means. Note the Teflon filter media is attached on the interior of the support ring so that the Teflon filter media will be in intimate contact with the filter holding means after it is installed.

Fig. 6 shows the Teflon filter media and the filter support ring before assembly. Note the assembly process does not require that the Teflon filter media be cut prior to attachment to the support ring.

Fig. 7 shows the filter holding means base and the filter support screen.

Fig. 8 shows a close up of Fig. 7. Note the filter support screen locating pins that provide additional strength of the assembly.

Fig. 9 shows the filter support screen that can be electroformed or chemically etched as well as fabricated out of sintered material that provides for a similar porosity as the hole array indicated.

Fig. 10 shows the side view of the filter holding means base. You can see the curved low mass support structure.

Fig. 11 shows an angle view of Fig. 10. Note the low mass support structure looks like the internal structure of an airplane wing.

Fig. 12 shows a top view of Fig. 10 with the low mass support structures.

Fig. 13 shows a bottom view of Fig 10.

Fig. 14 shows an exploded drawing of the complete assembly.

Fig. 15 shows an edge view of the complete assembly assembled consisting of all of the elements shown in Fog. 14..

Fig. 16 shows three views of a variant of the filter holding means, with a slightly curved top, using an exo skeleton design concept with external low mass support structures.